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27 November 1979

USSR Report

RESOURCES

No. 902

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CONSTRUCTION OF ATOMMASH DESCRIBED (PART I)

Tallin SOVETSKAYA ESTONIYA in Russian 5 Aug 79 p 3

[Feature story on the atomic energy facility "Atommash" by V. Simberg, staff correspondent of SOVETSKAYA ESTONIYA, Volgodonsk]

[Text] Look at the map of the country --
Here we are building our character.
The time of action is our days,
The scene of action is "Atommash"!

The verses in the epigraph of these travel notes are the refrain of a song published in the collection of prose and poetry "The Stars of 'Atommash'". The heart of our atomic power engineering is still under construction, but it is already glorified in many poems, stories, and even novels, not to mention articles and newspaper reports.

The author of these notes happened to participate in the work of a press conference on the problems of the origin of the personnel and the development of the production association of atomic power machine building "Atommash". "A giant who has no equal", "a marvel in the sky-blue Don steppe", and many other high-flown epithets emerged from every person who became acquainted with this unique structure. The plant amazes and enraptures everyone and, I must admit, and I am not ashamed of it, made me even dizzy. And why should I hide this, if even the Deputy Minister of Power Machine Building of the USSR, who is also the general director of "Atommash", Candidate of Technical Sciences Valeriy Grigor'yevich Pershin was not ashamed to say at a conference hall in front of a dozen of writers and journalists that a year ago when he had come to "Atommash" he was not himself for three days...

The reason why this happened will be explained by V. G. Pershin in the second part of these notes.

Before sharing my impressions of "Atommash", I suppose, I should refer to several authoritative statements. For a reader or even a journalist who is not a specialist in atomic power engineering, the name of the enterprise itself sounds unusually and alertingly. K. Gladkov, the author of the "pocket encyclopedia" -- "The Atom from A to Z", writes that a numerous category of

readers encounters in popular scientific books effective pictures of"strawberries" representing the nuclei of atoms flying in every direction.

The main component in the acronym "Atommash" is the atom. Everyone knows that atomic electric power stations operate with the energy released during the fission of atomic nuclei of uranium or plutonium. And here, at the Volgodonsk plant, AES [atomic electric power stations] will be produced in series. An ignorant person might think: "how many strawberries will be gathered in this basket?" But there is no radiation whatsoever at "Atommash". This is simply a machine building plant, and an unusual one.

The president of the USSR Academy of Sciences three times a Hero of Socialist Labor A. P. Aleksandrov assesses its significance in the following way:

"For many of us, physicists, 'Atommash' concludes a definite stage of life. It is an unusual plant. Here, today meets the future. The construction of such an enterprise is necessary because a large-scale development of atomic power engineering is inevitable... It is possible to say that 'Atommash', where atomic reactors will be created, will help in using fuel resources of the country rationally and, consequently, will strengthen our economy."

Time has confirmed what was said by the president of the USSR Academy of Sciences that "Atommash" is not only being built but it is already building. In the beginning of 1981, (according to the socialist pledges, even earlier), it must give to the country the first Don reactor. The heart of the atomic power engineering in Volgodonsk just started pulsating, but even now we can observe that more than 20% of the power of electric power stations introduced in our country during this five-year plan are atomic stations.

Journalists who are lyrically inclined describe the huge buildings of "Atommash" as turquoise, silvery white, and greenish blue. They really look like that. However, while I was writing these lines, I had two souvenirs in my hands. A heavy black bronze medal dated December 1978 which was issued in honor of the early completion of the construction of the first section. At that time, capacities for producing three million kilowatts of modern reactor equipment were put into operation. The participants of the construction of the plant and the operation workers were congratulated on the event of their labor victory by the Secretary-General of the CPSU Central Committee, Chairman of the Presidium of the Supreme Soviet of the USSR Comrade L. I. Brezhnev. And the first congratulation from him was issued to the "Atommash" workers at the end of 1976 when they put into operation building No 3 with an area of 30,000 square meters.

The assistant to the general production director familiarized a large group of journalists with the main plant building. It is truly huge. It will suffice to say that its production area (after the completion of the construction of the second section) will be 278,000 square meters. In three large areas 42 meters wide will be manufactured reactor shells, and in 30-meter areas will be located the production of the assemblies of steam generators and heat-exchange equipment. This part contains the blank-pressing,

assembling and welding, and thermal mechanoassembly shops. All technological processes and transportation operation here are mechanized and automated to a maximum. Provisions are made for organizing a system of control after each technological operation and output operations.

You cannot see from one end of the building to the other even through the binoculars. If you want to look at the roof, you have to take off your hat or it will fall off. The depth of special caissons intended for cold hydraulic tests and hot tests of pilot shells of reactors and steam generators is 20 meters and their size is 15 by 15 meters.

Chroniclers of "Atommash" recorded the paces of its construction: on 30 Aug 1975, a meeting was held at the location of the future main building concerning the concreting of the first cast-in-place pile; on 15 Aug 1978, Yu. Tikhonov's team started processing the parts of the first Don reactor in the main building. At the same time, work was started on the manufacturing of the first steam generator.

Looking at the installed and operating equipment of "Atommash", one sees custom-made lathes and units built by Soviet plants or supplied by foreign firms.

For example, there is a vertical boring machine about 15 meters high. It was built by the firm "Moranda". But Itallian specialists call it "Russian bull". Soviet engineers added their creative ideas to its design. And this is not the only case.

I had a chance to see how a shell of a reactor weighing 60 tons was machined on a universal turning and boring lathe produced in Kolomna.

The lathe operator, Aleksandr Dan'shin told me that he had been working for two years at "Atommash". At first he was engaged in assembling machines, but now he was entrusted with a more responsible job.

Aleksandr said: "As you can see for yourself, we have excellent and the latest equipment. Domestic and foreign equipment are standing next to one another. I prefer our domestic equipment. It is still the most reliable. Soon I am going to get an apartment..."

"Where did you come from? And why?"

"From Dagestan. Have you heard of 'Dagestanskiye ogni' [lights of Dagestan]?"

"That is not far from Derbent. A famous glass plant. When I was there about 10 years ago as a correspondent, they gave me a ball of fiber glass as a souvenir..."

Aleksandr Dan'shin smiled:

"Naturally, not a block of silicate. You wouldn't take a reactor shell with you from 'Atomash'. But I suppose you will not refuse a steel shaving rolled into a tight spiral... It will be a token of the first Don reactor."

The reader might think I am odd. Maybe I am. But the steel spiral still hot even after it was wrapped in a piece of white cloth by Dan'shin warmed my hand for a long time. How it is lying next to the little ball of fiber glass...

I only blame myself for the absurd question I asked: "Why Aleksandr came to Volgodonsk?" Of course, for the same reason as I did in 1966 when I wrote about my Dagestan encounters. In my accounts I cited the greeting telegram sent in 1926 to the builders of "Dagestanskiye ogni" by F. E. Dzerzhinskiy, chairman of VSNKh [Supreme Council of the National Economy]. It was short: "I am happy that the Union's first mechanized glass plant started operating and wish it vigilant and smooth operation. Let it be the basis for the development of the industry of the Dagestan Republic."

More than half a century has passed. Now the people of all our republics are rejoicing while building "Atommash", the first plant which is the heart of the atomic power engineering of our country. Evidently, it is not quite proper to ask why they are coming here.

[To be continued]

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CONSTRUCTION OF ATOMMASH DESCRIBED (PART II)

Tallin SOVETSKAYA ESTONIYA in Russian 7 Aug 79 p 3

[Part II of feature story on the tomic energy facility "Atommash" by V. Sim berg, staff correspondent of SOV SKAYA ESTONIYA,Volgodonsk]

[Text] Our country sent us here,
Having entrusted an important job to us.
It is like BAM and virgin land,
And there is no limit for daring.

It goes without saying that the entire country is building "Atommash" not only because its walls are being erected by children of various peoples, but also because more than 600 plants are working for it. Their addresses are: Moscow, Gor'kiy, Chelyabinsk, Ivanovo, Khar'kov, Dnepropetrovsk, L'vov, Minsk, Chimkent, Tashkent, Tbilisi, Yerevan, and Sumgait.

On the second day, the participants of the press conference went to meet people in the brigades and departments of the production association "Atommash", or to the trust "Volgodonskenergostroy". Many journalists tried to meet their countrymen. I was told at the Komsomol Central Committee of Estonia that there are people from our republic working in Volgodonsk. But where?

It was Saturday. The personnel departments were closed. At the headquarters of the All-Union Komsomol Shock Contruction, I was advised to see Yuliya Isakova about it. She was an instructor of the "Volgodonskenergostroy" party committee. She was just about to leave for the Saturday volunteer work, but agreed to help me out first.

Yu. G. Isakova was a journalist and an author and compiler of two collections: a chronicle of the shock construction project, "'Atommash' is my fate" and "The Heroic Feat is continuing". She remembered the arrival of our countrymen. She refered to them as well-built fellows and girls. She phoned the dormitories. There were Lithuanians and Latvians, but there was no one from Estonia.

Instead of their addresses I took with me the above-mentioned collections inscribed by the author and bought a third collection: "The Stars of 'Atommash'"...

But it did not contain even the smallest Estonian star that I needed so much. I had a printed letter of thanks with the "Atommash" stamp which I was going to bring back to the group of people whose envoys distinguished themselves at the construction project...

Then I decided to see the member of the public editorial board of the collection "The Heroic Feat is Continuing", V. G. Pershin.

V. G. Pershin, the general director, told me that, although he said at the press conference that he is at the service of the journalists, he meant only the press conference. Then he suddenly smiled and asked me: "How many weeks or days do you still have left for familiarizing yourself with 'Atommash'?"

I hesitated and said that I had 48 hours left.

"Monday is a heavy day. Then let's meet tomorrow, on Sunday at 10 o'clock in the morning. Does it suit you?"

"Of course, it does!"

At the appointed time I was sitting in front of Valeriy Grigor'yevich Pershin. The general director asked me about the informal farewell dinner that the "Atommash" people had for the journalists and was surprised to learn that I was not present. He asked me why I did not attend?

I explained that I was preparing for the interview and displayed on the table the three collections about "Atommash" and the prospectus issued to the participants of the press conference "The Giant of the Atomic Machine Construction Industry". The latter contained the following divisions: more energy is needed; ways of solving the problem; the geometry, organizational structure, and costs of "Atommash"; future prospects; events and facts.

And, of course, I also put on the table my pad with notes on V. G. Pershin's address and with my questions prepared for the interview. Here they are, with corrections, explanations, and additions by the general director.

[Question] Valeriy Grigor'yevich, when you spoke at the press conference to Moscow and Rostov writers, representatives of thick and thin magazines, and correspondents of numerous newspapers, you said that a year ago, after a detailed inspection of "Atommash", you were not yourself for three days...

[Answer] Let me explain why. There are many large plants in our country. They include the Izhorskiy Plant whose area is 3.5 times larger than that of "Atommash". I was familiar with many of them and directed a large production association. But it was not anything like "Atommash". The dimensions of production buildings ofthe present and future complexes are not important. The main thing is what is assembled and will be installed under these roofs.

I have recently visited the U.S.A. and found that there is no analogue of our Volgodonsk project, a peaceful cradle of reactors.

It is unique... However, I am not going to rephrase what has been stated in the prospectus. Its unique feature is the selection of the most perfect technological and special nonstandard equipment for one single purpose: highly productive and high-quality manufacturing of equipment for AES [atomic electric power stations].

[Question] What are the prospects for the production association?

[Answer] The resolutions of the 25th CPSU Congress defined a large-scale statewide program for accelerated development of atomic power engineering whose realization is of great importance for satisfying the increasing needs of the national economy. The most important part of this program is the creation of our plant. When it starts operating at its full capacity, the national economy of the country will receive equipment for units with reactors of a unit capacity of one million kilowatts and more.

Let me add the following. The development of "Atommash" will also depend on the scientific and technological achievements and on the prospects for the development of the main directions of power engineering. The general layout of the plant was developed with consideration for the construction of new buildings and shops. The fixed production capital includes the possibility for switching in the future to the production of still more powerful units.

[Question] The resolution of the CPSU Central Committee regarding the fiftieth anniversary of the first five-year plan of the USSR has been published...

[Answer] The strides of the five-year plans, their creative power and force can be seen all over the country. Particularly here, in Volgodonsk. Judge for yourself. During the first postwar five-year plan, the Volga-Don Canal was built, and then the man-made Tsimlyansk Sea and GES were created. Now it is "Atommash's" turn... Only do not consider it in isolation. Another plant is being built next to it and is growing together with our plant. It is a new satellite city which will become a model city... It is a port of five seas. But here you have to use your own imagination...

I told V. G. Pershin that I was returning from my trip with a bitter feeling, and he asked me to explain why.

I said: "Valeriy Gregor'yevich, I haven't been myself for three days, just as you were a year ago. Of course, for a different reason. Envoys of the Komsomol of Estonia worked well everywhere: on virgin land, in Tashkent after the earthquake, at the BAM [Baikal-Amur Railroad]. But here, I did not find any of our 28 fellows and girls. They are gone. Left their jobs...

The general director suddenly exclained: "Wait a minute, there were transient people at all construction sites. Those who left their jobs were good-for-nothing romantics and dandies. But, being your countryman, I will help you."

"But, first of all, let us be self-critical. It is we, the administrators of Volgodonsk, and you, journalists, who are responsible for the personnel turnover. We did not deliver separate rooms and apartments on the dates promised. It is true, however, that the builders in Volgodonsk did not live in tents and did not sleep by smoky bonfires. But you, journalists, sometimes write about Volgodonsk beautifully, but not quite truthfully. Yes, "Atommash" is calling you' We need builders, and welders are particularly needed at operating plants."

"And since you took me as a bull by the horns, do not be hurt. You can derive much good from your short trip. For this, don't hesitate to squeeze out the information from the collection of your colleagues, other journalists. There is a good statement about Volgodonsk in the essay "Peaceful Front". Quote the paragraph "'not everyone settles here forever. Some thought that, having arrived at 'Atommash', they will immediately be given three-room apartments with a veiw of the sea. They were told: 'build and you will get them.' 'When are we going to get them?' -- 'When you build them'. This did not suit them, because they wanted everything ready for them immediately. Then they were told: 'Nobody is keeping you here.' And they were right to tell them that: you can't expect anything good of such people."

Secondly, we have the framework, but not an established personnel with good traditions. It is being crystallized. Those who are wearing "Atommash" emblem on their helmets must realize how fortunate they are to be building and working at plantswhere today and tomorrow meet. This thesis can be repeated twice and thrice..."

I said: "Before my trip to 'Atommash' I knew that a new team of volunteers for 'Atommash' is being formed in Estonia."

V. G. Pershin answered: "That's fine. Right: 'Atommash' is calling you!' It is calling those who will observe the code of our personnel. We work harmoniously,honestly, we study, improve our skills, respect friends and rules of socialist society."

[Question] What would you like, Valeriy Grigor'yevich, to wish the readers of 'Sovetskaya Estoniya'?

[Answer] What can a power engineer and machine builder wish? Energy. But I also have a request of a countryman. In 1950, I graduated from the 4th Tartu Secondary School. It is a wonderful school. After ten years, I am sending my thanks to all its teachers, and particularly to the kind, intelligent, and charming woman, our class advisor, Armil'da Yanovna Palu. I have the best memories of Estonia and many of my friends...

[Question] Valeriy Grigor'yevich, journalists at the press conference asked you when you will start writing, and you answered that you never let the pen out of your hand,and that it is your main production tool...

[Answer] "What about it?"

Use it, sign the interview directly on the pad.

"Let it be so," said my countryman.

The third and concluding part of my notes will deal with the new satellite city of "Atommash": Volgodonsk, which, quite possibly, could be called Atomgrad some day.

V. G. Pershin, Deputy Minister of Power Machine Building of the USSR, General Director of the Plant "Atommash."

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ELECTRIC POWER AND POWER EQUIPMENT

NEW GES ON DAUGAVA RIVER UNDER CONSTRUCTION

Moscow IZVESTIYA in Russian 29 Aug 79 p 1

[Article by Ye. Vostrukhov, staff correspondent of IZVESTIYA, Riga]

[Text] The construction of a large hydroelectric power station, the fourth on the Daugava River has been started in the eastern part of Latvia.

Early in the morning, columns of heavy equipment started moving to the right flood-land bank of the river. Dump trucks and excavators concentrated at the edge of a sparse pine forest. It is here, several kilometers away from Daugavpils, the width of the river is the most convenient for the erection of the powerful dam more than 100 meters high and almost one and a half kilometers long. The excavator, Nikolay Anan'yevich Chapaldy, has participated in the construction of the first three GES of the Daugava Cascade in the lower reaches of the river: Rizhskaya, Kegumskaya, and Plyavin'skaya GES. Today, he will remove the first bucket of ground from the trench of a new hydroengineering complex.

The first load of ground has been loaded in the dump trucks, the first cubic meters of the 3.9 million cubic meters which will be removed from the flood land of the Western Dvina River.

N. Cherepanov, the head of the recently created administration DaugavpilsGESstroy, said, "The builders of the complex have to perform a large volume of work: to pour 2.3 million cubic meters of earth and 300,000 cubic meters of concrete and to assemble 13,000 tons of various equipment and metal structures. The period set for the construction of this hydroengineering complex is very short: the new GES must be put into operation during the next five-year plan as a part of the operating stations of the Unified Energy System of the northwest of the country."

The new GES is being built at the junction of the territories of three sister republics: Latvia, Belorussia, and Lithuania. It will play an important role in further development of their productive forces. This high dam will make it possible to create a man-made sea here: the reservoir will extend from Daugavpils to Polotsk over 200 kilometers and will take in 700 million cubic meters of water. It will connect these two industrial centers, will make the

Daugava River navigable, and will solve the problem of water supply for the rapidly growing cities. At the same time, the wide dam will be used as a reliable bridge for the Leningrad-Kaunas highway and railroad.

The future station, just as the first three stations on the Daugava, will be a so-called peak station. All of them are intended primarily for covering "peak loads" during the hours of the highest consumption of electric energy during the day. In spite of their relatively low capacities, their role in the unified energy system is extremely great. The water reservoir which is being created near Daugavpils will increase the maneuverability and reliability of the operation of all stations of the cascade, will make it possible to regulate evenly the runoff of the river during the entire year, and will make it possible to put a stop to useless discharge of water in the spring during the ice-flowing period. According to the calculations of the designers, with the seasonal regulation of the runoff of the Daugava, the production of electric energy by all stations of the cascade will increase by more than 600 million kilowatt-hours a year.

Simultaneously with the entire complex of the station, a settlement for the builders and power engineering workers will be built on the right bank of the Daugava. After this complex, it is planned to start the construction of the next higher stages of the cascade: Yekabpilsskaya and Vitebskaya GES.

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NUREKSKAYA GES BECAME OPERATIONAL

Moscow STROITEL'NAYA GAZETA in Russian 3 Oct 79 p 1

[Article by V. Il'in]

[Text] The Nurekskaya GES reached its design capacity 15 months ahead of schedule.

The machine room of the hydroelectric station on the Vakhsha River was crowded last Sunday. V. Lyul'chak, chairman of the state commission, made the following entry in the start-up log: "Permission is given to include the ninth unit in the Central Asian Energy System." Then the operator on duty, V. Pil'shchikova, delegate of the 18th Congress of the VLKSM [All-Union Lenin Young Communist League], came to the center of attention. She turned the key at the control board, and the ninth unit started producing its first kilowatt-hours of electric energy.

Among those present was the main designer of hydrogenerators of the plant Uralelektrotyazhmash , V. Lashkarev. The staff of this enterprise produced the country's first special-purpose rotor with water cooling for the 9th unit. The designers, operators, assemblers, and adjusters made it possible to reduce the idling testing of the unit by one week. This was another impressive example of the effectiveness of competitions on the principle of "Work Relay Race" due to which the Nurekskaya GES reached its design capacity 15 months ahead of schedule.

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DEFECTS IN POWER EQUIPMENT CONFIRMED

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 8 Sep 79 p 2

[Article by Deputy Minister of Power and Electrification V. Kozhevnikov and Chief of the Technical Board of the Ministry of Electrical Machine Building V. Plastov]

[Text] Deputy Minister of Power and Electrification of the USSR V. Kozhevnikov answered the following to an article of SOTSIALISTICHESKAYA INDUSTRIYA:

The article "Deadlines have passed ..." published in SOTSIALISTICHESKAYA INDUSTRIYA on 25 April of this year correctly noted the great national economic significance of technological power treatment of fuel and defects in the construction of units "UTT-3000" at the Estonskaya GRES and "ETKh-175" at the Krasnoyarskaya TETs-2.

The ministry has mapped out a complex of measures for ensuring the fulfillment of the plan of work on "ETKh-175" in 1979 and completion of the installation of the unit in 1980.

At the present time, the construction of "UTT-3000" is under constant control of the ministry. The schedule for the completion of construction and installation jobs has been approved. According to schedule, the "UTT-3000" unit will be put into operation in the third quarter of 1979.

V. Plastov, head of the Technical Administration of the Ministry of Power Machine Building, replied the following to the article A Chronicle of Delays [SOTSIALISTICHESKAYA INDUSTRIYA, 7 Aug 1979]: The article justly criticized the Ministry of Power Machine Building for delivering poor-quality steam generators for the NGDU [Oil and Gas Extraction Administration] Starogrozneft'.

It is true that defects for which the production association Krasnyy kotel'shchik was responsible were revealed in individual assemblies of steam generators "PR-10/120". A team of specialists of this association removed all the defects, and the steam generators have been put into operation. To prevent repetition of such cases in the future, additional reinforcement of the burner and pipes was introduced in the design. The department of technical control of the enterprise has established procedures for the approval of steam generator assembly jobs.

Moreover, the production association Krasnyy kotel'shchik and scientists were instructed to establish control over the operation of steam generators.

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PRESS, TV, AND RADIO WORKERS MEET AT 'ATOMMASH'

Moscow EKONOMICHESKAYA GAZETA in Russian No 40, Oct 79 p 4

[Article by V. Sidorenko, staff correspondent]

[Text] A meeting of press, television, and radio workers was held in the city of Volgodonsk on the subject "Patronage of Journalistic Organizations Over 'Atommash'". It was organized by the Union of Journalists of the USSR and the Rostovskaya Oblast Party Committee.

This giant of the domestic atomic power machine building industry grew in the Don steppe in a short period of time. The plant is still under construction, but the production of the first reactor for an AES [atomic electric power plant] is already in full swing in the shops that have been completed. The personnel pledged to complete its construction ahead of schedule. The participants of the meeting familiarized themselves with the state of affairs at the construction site and in the operating shops, and visited construction sites in the city of Volgodonsk.

The meeting was opened by the secretary of the board of the Union of Journalists of the USSR, L. N. Yagodin. I. A. Bondarenko, first secretary of the Rostovskaya Oblast Committee of the CPSU, reported on the work of the oblast party organization in connection with the fulfillment of the resolutions of the 25th CPSU Congress, acceleration of construction, and making the "Atommash" fully operational. N. I. Semenyuta, chairman of the board of the oblast organization of the Union of Journalists of the USSR and editor of the newspaper MOLOT, shared the patronage work of Rostov journalists over the construction projects of "Atommash".

Other speakers at the meeting were: Deputy Minister of Power and Electrification of the USSR A. N. Semenov, Deputy Minister of Installation and Special Construction Work of the USSR Z. S. Sadardinov, general director of the association "Atommash", Deputy Minister of Power Machine Building V. G. Pershin, leader of the lathe operators brigade of "Atommash" A. S. Savranskiy, Secretary of the"Atommash" Party Committee L. I. Popov, general director of the VPKTI [All-Union Planning, Design and Technological Institute]"Atomkotlomash" K. P. Petrenko, and assistant to the chief editor of EKONOMICHESKAYA GAZETA V. F. Filippov.

The following presented reports at the meeting: M. S. Kryukov (PRAVDA), V. I. Lifanov (SOTSIALISTICHESKAYA INDUSTRIYA), V. N. Raskin (TRUD), G. P. Panushkin (STROITEL'NAYA GAZETA), V. F. Minyaylo (Rostov radio and television), A. S. Klyunenko (INDUSTRIAL'NOYE ZAPOROZH'YE), M. D. Mamadrizoyev (TADZHIKISTON SOVETI). The results of the meeting were summarized by S. S. Slobodyanyuk, instructor of the Department of Propaganda of the CPSU Central Committee.

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CLASSIFICATION OF PETROLEUM RESOURCES

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[Text] The classifications of petroleum resources developed in the USSR and the United States are now in the most common use. With small modifications they are being used in different countries of the world. These classifications are based on two fundamental classifications of mineral reserves developed at the beginning of the current century.

One of these, proposed by the London Institute of Mining and Metallurgy, is based on the principle of the difference in the degree of preparation of the mineral for production. Another classification, formulated by the mining engineer H. C. Hoover, for the most part takes into account the degree of production risk, dependent on the degree of exploration of the mineral [1].

The formulation of the first classification of petroleum reserves in the USSR was in 1928 by a commission of the Geological Committee, created for carrying out the first calculations of petroleum reserves in the country.

The classification provided for the classifying of reserves on the basis of the degree of their preparation for extraction from existing boreholes. Three categories were used: A — "prepared reserve," that is, the quantity of petroleum which can be extracted using existing boreholes with their exploitation to the minimum economically advantageous yield; B — "explored reserve," that is, the quantity of petroleum which can be extracted from strata within the limits of a defined petroleum-yielding area by new boreholes with their exploitation to the minimum economically advantageous yield; C — "assumed reserve," that is, the quantity of petroleum which can be extracted from strata in a deposit beyond the limits of the established outline of the petroleum-yielding area or an area inadequately explored by drilling.

During subsequent years it was considerably improved by I. M. Gubkin, D. V. Golubyatnikov, V. V. Bilibin, M. V. Abramovich, M. A. Zhdanov and other geologists.

The classification of petroleum reserves has been periodically (in 1932, 1937, 1942, 1953, 1959 and 1970) re-examined for bringing it into correspondence with the changing conditions for reconnaissance and commercial use of petroleum deposits.

After official approval of the fundamental principles of the classification of reserves by the USSR government, it legally established unified principles for reckoning and inventorying reserves. With time the development of long-range plans for the further increased development of the Soviet Union petroleum industry required the broader use of estimated predictions of the petroleum reserves in individual regions of the country. For this reason the classification of petroleum resources was broadened and such concepts as "quantitative estimated prediction of petroleum resources," "potential resources" (initial and current) etc. were introduced.

The classification of petroleum resources in the USSR in its present-day form is based on the principle of the difference in the degree of geological-geophysical study of deposits, pools, their individual parts, and also structures (traps) and territories promising for petroleum.

Accordingly, four categories of reserves are defined (A, B, C_1 and C_2) and a group for quantitative estimated prediction of petroleum reserves (D). The reserves in categories A, B and C_1 are calculated within the limits of a deposit with proven petroleum reserves, but differ from one another with respect to the accuracy in determining the calculated parameters. Reserves in category A have been studied in detail and are calculated in the process of working of the deposits. Reserves in category B also to a high degree are reckoned after drilling of the petroleum deposit by operational boreholes and refinement of commercial geological parameters [2].

Reserves of category C_1 are calculated for the most part in the exploration stage because deposits are exploited if the reserves in category B are 20% of the sum of reserves of categories B and C_1 (the exploitation of deposits having a complex geological structure is allowed completely in reserves of category C_1).

Reserves of category C_2 are noncommercial and extremely varied in composition. They include reserves of unexplored sectors of open deposits, promising horizons with undetermined petroleum resources in known deposits, and also structures (traps) promising for finding the presence of petroleum, situated in regions where the presence of petroleum has been established.

The group for quantitative estimated prediction of petroleum reserves is a result of a quantitative estimate of the prospects of finding petroleum in lithological-stratigraphic complexes or individual horizons, which is accomplished on the basis of an analysis of the geological criteria for presence of petroleum. On the basis of the degree of geological-geophysical study of the prediction territories it is divided into two subgroups — D_1 and D_2. As the principal criterion for subdividing the predicted estimate into the mentioned subgroups use is made of the fact that the presence of petroleum has been established in a particular lithological-stratigraphic complex

within the limits of a major tectonic form (arch, depression, large swells, marginal troughs or foredeeps, intermontane troughs, etc.). In petroleum geology regionalization, providing for the discrimination of such nomenclature units as region, oblast and province, the concept "petroleum-bearing oblast" usually corresponds to this major tectonic form.

All petroleum reserves of the mentioned categories and the group for quantitative predicted estimate of reserves are combined under the term "initial potential resources," and without taking into account already extracted reserves (accumulated yield) — "current potential resources."

The principle of economic feasibility of working of reserves has found reflection in their division into "balance" and "extra-balance."

One of the most important principles for the classification of petroleum reserves is the requirement for ensuring a high degree of exploitation of the reserves and the use of deep layers.

The possible coefficient of petroleum extraction with which the reserves are calculated must be determined by technical and economic computations which take into account the use of the most progressive methods for the working of petroleum deposits. However, it must be guaranteed and ensured by existing technological, technical and economic possibilities.

However, for many deposits in the country the value of the final coefficient of petroleum extraction which has been adopted is clearly exaggerated and there are significant discrepancies between its proposed and actual values. This is evidence that in the stage of confirmation of reserves at the USSR State Committee on Mineral Resources an inadequate allowance was made for a great number of factors determining the petroleum extraction coefficient. Accordingly, it is necessary to increase the scientific level of validation of this coefficient and other indices of "conditions" for new deposits, and also to improve the system for their inspection and confirmation.

The presently adopted classification of petroleum reserves is not without some shortcomings. These include the absence of a clear discrimination between discovered and undiscovered resources, as a result of which the category of reserves C_2 is extremely diverse in its composition. It is also undesirable to divide a single group of commercial reserves into three categories (A, B and C_1).

In order to develop the petroleum industry it is sufficient to have one commercial category of reserves (instead of three), but ensuring reliable planning of systems for the working of deposits and planning of petroleum output.

Also not taken into account is the difference in the degree of commercial significance of the reserves. This principle will be reflected only in a supplementary classification of petroleum resources [3]. However, the use

of this principle is of great importance for a correct evaluation of the achievable possibilities and the state of the raw material base in each petroleum-producing region and in the country as a whole.

The scheme for the classification of petroleum resources proposed by the authors of this article takes the principles expounded above into account. It was developed on the basis of existing concepts and categories and does not require radical changes in the already adopted practice of evaluation of reserves.

It is recommended that four principles serve as a basis for the proposed classification of petroleum resources and their evaluation:
-- the degree to which the resources have been studied;
-- the economic feasibility of working the resources at the present time (profitability);
-- commercial significance of the resources;
-- possible completeness of use of deep layers and exploitation of the resources in deposits.

In order to preclude the possibility of a contradictory interpretation of individual classes, instead of vague names or letter designations we propose that they be given a clear characterization.

In formulating a classification of petroleum resources there should be a reflection of the state not only of the quantity of petroleum to be extracted, but also its total content in the strata. It is difficult to show this in a single scheme, since it would be an extremely unwieldy diagram. Therefore, the proposed classification scheme is recommended for use in characterizing both extractable resources and the total quantity of petroleum in strata.

In order to create a scientifically sound classification of petroleum resources it is necessary to solve the problem of terms.

The term "reserves" in its meaningful content applies to that which has been stored up. However, there is a clear noncorrespondence between the definition of the term "reserves" and its use in the practice of geological prospecting work and in an evaluation of the state of petroleum and gas resources.

In the existing classification of petroleum and gas reserves the term "reserves" is applied to still undiscovered deposits. Thus, reserves of category C_2 are evaluated not only with respect to unexplored sectors of discovered deposits, but also with respect to objects in which the presence of petroleum and gas has not been established (unexplored horizons of known deposits and promising structures in petroleum-bearing regions).

Until recently the term "reserves" has even been applied to the estimated prediction of poorly studied territories. Such a broad understanding of the term "reserves" creates a distorted idea concerning the actually discovered

and "stored up" quantities of petroleum and gas. Restriction of use of the term "reserves" was proposed in [4].

The term "reserves" should be applied only to that quantity of petroleum which has already been explored (or has been discovered and is adjacent to explored reserves) and which can be extracted with existing technological, technical and economic capabilities. Then the quantity of petroleum which has not yet been discovered or explored and which cannot for the time being be extracted with existing technological, technical and economic possibilities must be given the name "resources." It must be noted that in our country a definite step has already been taken in this direction when the term "predicted petroleum reserves" was withdrawn from use and replaced by the term "quantitative predicted estimate of presence of petroleum" (it would be more correct to call this the "quantitative estimate of undiscovered petroleum resources").

The term defining the total quantity of petroleum in the ground also lacks the necessary clarity. In the USSR the term "geological reserves" is used for this purpose, but in actuality, the reserves are only the extractable part (averaging 30-60%) of that present in the ground. In the United States the term "oil in place" is used; this is also not precise.

It would be correct to use the term "total volume of petroleum in a stratum" because this most completely reflects the meaningful content of the considered concept. However, it is inadequately convenient for statistics and for general use. Therefore, as its conditional synonym it is recommended that the term "stratum volumes" be employed. Thus, the term "extractable" can refer to both "reserves" and "resources," whereas the term "stratum volumes" refers only to "resources."

It is more convenient to examine the remaining terms and concepts in the exposition of the essence of the proposed classification of petroleum resources (see table).

The term "discovered resources" takes in the resources of already discovered petroleum deposits. In this case there are reliable data on the parameters of the stratum, the quality of the petroleum and the working conditions. The existence of "undiscovered" petroleum resources is only postulated on the basis of favorable results of geological-geophysical investigations of individual structures (traps) and territories and also theoretical concepts. Undiscovered resources are determined as a result of a quantitative predicted estimate of the presence of petroleum.

As a term combining the two mentioned groups of resources (discovered and undiscovered) we propose use of the term "initial potential resources," and without taking into account the already extracted reserves (accumulated yield) -- "current potential resources."

The discovered resources, taking into account the profitability of their exploitation at the present time, are subdivided into profitable and unprofitable.

The resources entering into the subgroup of unprofitable ("extra-balance") are regarded as possible for commercial use only in the future, since at the present time their exploitation is unprofitable for a number of reasons. Here we must include the resources which may become extractable (that is, reserves) with an improvement in existing exploitation systems, which now are ineffective for these deposits and pools. The principal factor determining the possibility of improving exploitation systems is economic feasibility. The systematic calculation and analysis of petroleum resources in this subgroup will increase attention to improvements for increasing the petroleum yield of strata in workable deposits.

The discovered profitable resources correspond to the concept "reserves" and are subdivided into:
-- extracted reserves (accumulated yield);
-- explored reserves (current);
-- reserves of unexplored sectors of discovered deposits (adjacent to explored reserves).

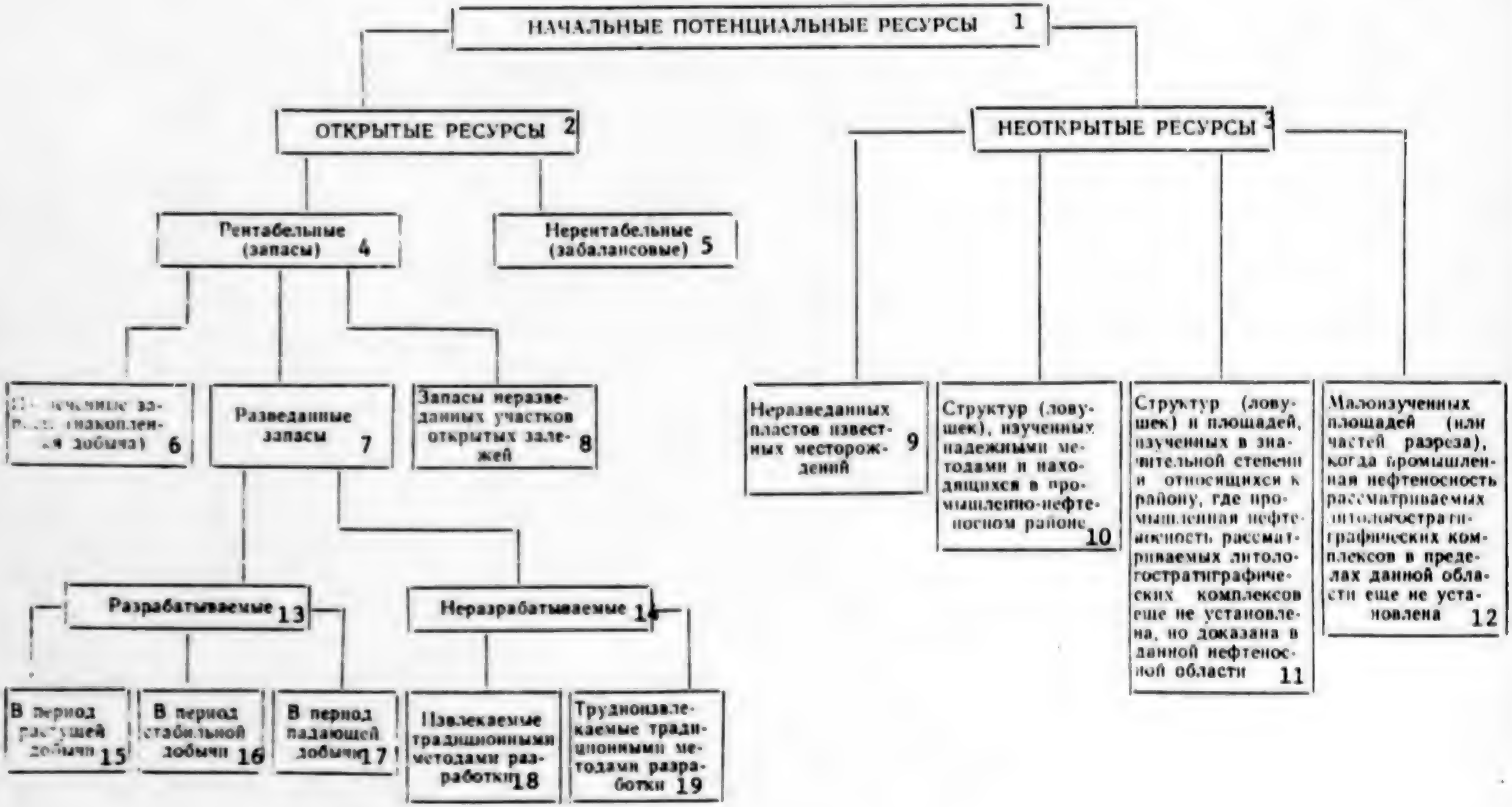
The subgroup of extracted reserves (accumulated output) is a component part of the discovered resources and its discrimination is necessary for a proper characterization of the overall state of resources and the degree of their use.

The subgroup of explored reserves is the basic one in the classification because it determines the existing achievable possibilities. By its very nature this subgroup should include reserves explored to a sufficient degree for beginning their exploitation and drawing up of a technological plan for the exploitation of the deposit.

Depending on the stage of commercial use, this subgroup is broken down into exploited and unexploited. Such a division makes it possible to characterize the degree of exploitation of explored reserves and also to evaluate the prepared reserves for increasing the petroleum yield in the country.

It is possible to recommend a more detailed characterization of the explored petroleum reserves on the basis of their commercial significance. As is well known, the first period of exploitation of petroleum deposits (to the time when the planned yield is attained), corresponding to the period of increasing output, is short. During this time 20-30% of the initial extractable reserves are exploited. A long period of deposit exploitation, during which the greatest volume of its reserves is exploited, almost always transpires under conditions of stabilization or dropoff of yield. Therefore, the breakdown of petroleum reserves into those exploited during periods of increasing, stable and decreasing yield considerably refines the achievable possibilities of the exploited deposits.

Unexploited reserves can be differentiated on the basis of their commercial significance into exploitable and those difficult to exploit by traditional methods. The latter include reserves of petroleum with a high viscosity,


НАЧАЛЬНЫЕ ПОТЕНЦИАЛЬНЫЕ РЕСУРСЫ 1
ОТКРЫТЫЕ РЕСУРСЫ 2
НЕОТКРЫТЫЕ РЕСУРСЫ 3
Рентабельные (запасы) 4
Нерентабельные (забалансовые) 5
(накопленная добыча) 6
Разведанные запасы 7
Запасы неразведанных участков открытых залежей 8
Неразведанных пластов известных месторождений 9
Структур (ловушек), изученных надежными методами и находящихся в промышленно-нефтеносном районе 10
Структур (ловушек) и площадей, изученных в значительной степени и относящихся к району, где промышленная нефтеносность рассматриваемых литологостратиграфических комплексов еще не установлена, но доказана в данной нефтеносной области 11
Малоизученных площадей (или частей разреза), когда промышленная нефтеносность рассматриваемых литологостратиграфических комплексов в пределах данной области еще не установлена 12
Разрабатываемые 13
Неразрабатываемые 14
В период растущей добычи 15
В период стабильной добычи 16
В период падающей добычи 17
Извлекаемые традиционными методами разработки 18
Трудноизвлекаемые традиционными методами разработки 19

KEY TO TABLE:

1. Initial potential resources
2. Discovered resources
3. Undiscovered resources
4. Profitable (reserves)
5. Unprofitable ("extra-balance")
6. Extracted reserves (accumulated yield)
7. Explored reserves
8. Reserves of unexplored sectors of discovered deposits
9. Unexplored strata of known deposits
10. Structures (traps) studied by reliable methods and situated in commercial petroleum-bearing region
11. Structures (traps) and areas studied to a considerable extent and belonging to a region where commercial presence of petroleum in the considered lithological-stratigraphic complexes has not yet been established but has been demonstrated in the particular petroleum-bearing region
12. Poorly studied areas (or parts of section) when the commercial presence of petroleum in the considered lithological-stratigraphic complexes has not yet been established within the limits of the particular region
13. Exploited
14. Unexploited
15. During period of increasing yield
16. During period of stable yield
17. During period of decreasing yield
18. Extractable by traditional exploitation methods
19. Difficult to extract by traditional exploitation methods

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deposits beneath gas strata, petroleum zones inundated with water, collectors of complex structure, and also reserves in small pools.

The subgroup of reserves of unexplored sectors of discovered deposits includes reserves reckoned in the area between a sector with explored reserves and the projected contour of the zone containing petroleum. This subgroup is the immediate reserve for preparing new explored reserves. According to the classification now in use in our country, this subgroup should include the most reliable part of the reserves of category C_2 (and possibly some part of C_1).

Undiscovered petroleum resources are determined as a result of a quantitative predicted estimate of petroleum presence in geological structures which differ with respect to the degree of their study and the valuation of prospects.

It is proposed that four subgroups of resources be distinguished.

1. Unexplored strata of known deposits.

The commercial presence of petroleum in these strata is predicted on the basis of an analogy with productive horizons in the particular or adjacent deposits.

2. Structures (traps) studied by reliable methods and existing in a commercially petroleum-bearing region.

The prospects of such structures are predicted on the basis of a geological analogy with adjacent deposits.

The success of exploration of such structures usually falls in the range 30-60% and therefore in a determination of the total petroleum resources for a major region as a whole it is necessary to introduce an appropriate correction.

3. Structures (traps) and areas studied to a considerable extent and located in a region where the commercial presence of petroleum has not yet been established in the considered lithological-stratigraphic complexes, but has been demonstrated in the particular petroleum-bearing region. The presence of petroleum resources is predicted on the basis of a geological analogy with some region in the particular petroleum-bearing region where the commercial presence of petroleum has been established in this same lithological-stratigraphic complex.

4. Poorly studied areas (or parts of a section), when the commercial presence of petroleum in the considered lithological-stratigraphic complexes has not yet been established within the limits of the particular region (or major tectonic structure). In this case the prediction is made on the basis of an analysis of general geological criteria for the presence of petroleum and theoretical concepts. Use is also made of a geological analogy with other major tectonic forms, where the evaluated lithological-stratigraphic complex is petroleum-bearing.

The principal criterion for discriminating the last two subgroups is the fact that commercial presence of petroleum has been established in a particular lithological-stratigraphic complex within the limits of a major tectonic form -- a first-order structure, which is arbitrarily equated to a petroleum-bearing oblast.

Thus, without changing the existing requirements on individual categories of reserves, the proposed scheme for the classification of petroleum resources clearly determines their position in the general scheme and makes possible a quite complete characterization of the state of exploration and use of petroleum resources.

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FUELS AND RELATED EQUIPMENT

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ECONOMICS OF LONG-TERM PLANNING OF OIL INDUSTRY GROWTH, SITING

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[Article by R. Sh. Mingareyev and A. Z. Kuz'min, All-Union Scientific Research Institute of the Organization of the Control and Economics of the Oil and Gas Industry]

[Text] The 25th CPSU Congress drew up the party's economic strategy for the near-term and long-term future. Managing the economy better is a vital part of this program. The great new scope of industrial production in our country, the tremendous sweep of capital construction, and the carrying out of the scientific and engineering revolution demand the concentration of resources needed for fulfilling the most important nationwide programs, the more rational combination of current and long-term problems and ensuring the full balancing of the economy of all spheres of material production.

To the raw material industries, and above all to the petroleum industry belongs an exceptionally important role in meeting these challenges.

When examining the economic problems of the petroleum industry's growth and siting in today's conditions, we must start from the principal task of the Tenth Five-Year Plan defined by the 25th CPSU Congress--to ensure the further growth and raise the efficiency of social production.

In each particular industry this challenge must be met with allowance for the specifics of its growth.

The USSR petroleum industry today is one of the most dynamic sectors of the economy.

The successes won in the petroleum industry became possible through special programs, above all, the establishment of a base of raw material resources in the country. It is specifically through the discovery of new deposits that the prerequisites were laid down for a growth in recovery in regions like Western Siberia, Kazakhstan (Mangyshlak peninsula), Belorussia, Orenburgskaya and Permskaya oblasts and Udmurtskaya and Komi ASSR.

Prominent among the new regions is Western Siberia. Mastering Western Siberia is an example of the broad use of the very latest achievements in science and technology, the application of modern methods of exploiting oil fields and well drilling and the wide-ranging automation and mechanization of production processes.

Much work in maintaining the oil recovery level was done in the old regions of the country through measures for stimulation and inclusion in exploitation of new fields and areas.

Scientific and engineering progress served in dealing with heavy and many-sided challenges in capital construction, drilling operations and other parts of the petroleum industry.

Industrialized methods of building up surface workings at oil fields with integrated-block automated installations were broadly introduced.

Continued growth of the petroleum industry makes it necessary to search for, explore and include in exploitation new oil fields in Western and Eastern Siberia, the Caspian Lowlands, the Komi ASSR, Arkhangel'skaya Oblast and so on.

All these and other factors must be reckoned with when we examine the problems of long-term growth of the industry.

A decline in the effectiveness of exploratory-prospecting drilling is anticipated in the years ahead. So the industry's growth will proceed, it appears, against a background of many small oil fields being discovered.

Discovery and then initial exploitation of these fields require a considerable increase in the volumes of exploratory and exploitation drilling.

One of the vital economic problems of the industry is the concentration of exploratory and prospecting work in the most promising directions.

All this presents heavier demands on geological scientific and production organizations in improving methods for determining oil reserves and on the level of planning geological prospecting activity. Planning of this activity, it appears, must be done separately in two directions: exploratory and prospecting drilling.

Exploratory drilling must be examined from the standpoint of the discovery of new oil reservoirs.

To us it appears that against this background a different approach is needed in planning technical and economic indicators and for drilling organizations doing this kind of drilling. Both new indicators and new forms of stimulation, it appears, must be worked out—in a word, the kind of economic cost accounting that would attract production collectives in conducting operations in new areas.

exploratory drilling must be examined from the standpoint of providing the industry with commercial reserves.

The program to provide the industry with crude reserves must take in not just indicators like increment in reserves, volumes of exploratory drilling and its effectiveness, expressed in tons per meter and in tons per well, but also a complex of other activities associated with designing and building new equipment, machinery and mechanisms, production bases, with assuring energy capacities and road construction and in resolving the social problem. An approach to planning exploratory and prospecting activities from these standpoints will mean the industry's growth through prepared reserves.

The probabilistic nature of a predictive estimate of a large part of the potential reserves gives rise to indeterminacy in finding recovery levels over the long term. At the same time, the possible oil recovery levels must be determined as accurately as possible, since it is already necessary right now to start constructing up-to-date petrochemical complexes and to produce equipment and facilities for installations making alternate forms of fuels. Also, these complexes and installations, after initial commissioning, must be supplied with crude reserves for several years into the future. So long-term planning of oil recovery is becoming a challenge of great practical importance.

One avenue toward coping with the challenge of long-term planning against the background of incomplete information is substantiating the upper and lower oil recovery levels with a quantitative estimate of their reliability. And the reliability of the lower limit of recovery will prove to be the highest.

One economic problem surfacing in long-term planning is the problem of setting up the capacity of new wells that reflect the specifics of our industry and is associated with characteristics of oil field exploitation.

We know that oil recovery rises in the initial period of field exploitation, then stabilizes and, finally, decreases. Statistics in recent years show that at the general level of oil recovery eached in our country, the decrease in recovery is very pronounced.

In the time span we are looking at, when the number of regions entering the last stage of their development grows, the capacities of new wells needed just to compensate for the drop in oil recovery at the old wells will grow at rates faster than the oil recovery level in the industry.

In this situation facing us is the task of a substantiated determination of the required volume of new well capacity, on the one hand, and more effective well utilization--on the other.

The problem of maintaining the oil recovery level in the old traditional regions is a problem of extraordinary importance. One of the most crucial

tasks here is making capital investments more effective. These problems are now being investigated; recommendations are being drawn up on improving the planning of capital investments and on the more effective use of fixed assets.

Fuller and more rational utilization of natural resources is a vital national-economic problem. In the petroleum industry there is growing significance in questions associated with the fuller recovery of petroleum from oil fields. At the present time a broad program for introducing new methods of boosting stratal oil returns has been developed. To solve this problem in the industry, it has been permitted to set up a special fund for boosting stratal oil returns. The fund must compensate for heavier costs during the time when new methods are being made operational and must stimulate their adoption. These and other measures will spur a rise in the national-economic effectiveness of oil field exploitation.

The oil industry's growth ties in closely with the mastery of oil regions characterized by unfavorable physical-geographical and natural-climatic conditions. Classed with these regions is the Komi ASSR, Arkhangel'skaya Oblast, the northern part of Western Siberia, a large part of Eastern Siberia and, in part, the Far East.

Intensive growth of oil production requires a large volume of work in preparing reserves, setting up capacities for oil recovery and commissioning capital construction projects.

The program for utilizing casing-head gas stands in a wholly special position. The primary goal indicator of this program--higher utilization of casing-head gas--can be achieved above all through a radical improvement in the utilization of gas reserves in Western Siberia.

At the same time, today Western Siberia is among the regions where the situation is not at all favorable with regard to the utilization of this value feedstock of the petrochemical industry.

The situation will improve very decidedly when new gas refineries go on stream in this region in 1980, but considerable effort will be needed to increase the use level of the gas through constructing gas refineries, compressor stations, wet and dry gas pipelines, product pipelines, desulfurizing installations and so on.

Further progress in the oil industry requires increasing the volume of drilling operations, the number of drilling rigs and other equipment, as well as increasing the scale of the entire auxiliary services--transportation, repair and power services and an appropriate rise in the number of personnel with the full complex of social and everyday living conditions.

An alternative to this solution of the problem can be only a stimulation of all drilling operations.

Experience with the best drilling organizations demonstrates that the mastered and introduced achievements in domestic and foreign science and technology permit raising the productivity of drilling rigs by a multiple number of times. This solution will mean the possibility of mastering the projected volumes of drilling work with a heavy increase in the number of personnel and the production equipment of the drilling service.

Stimulation of drilling services calls for developing and carrying out a special program of capital equipment updating of drilling work as applied to the conditions of the northern and eastern regions.

New high-productivity drilling rigs, technical means for their rapid transfer and installation, high-productivity cutting tools, modern flushing services, high-quality drilling and casing pipe and much else need to be built.

The program must provide for involving allied industries in its execution, as well as the broad application of the best foreign experience.

The problem of labor resources is the most important economic problem that must, evidently, be dealt with in the long-term planning of the industry's growth. The influx of able-bodied population will diminish in the years to come (aftermath of the war).

Calculations show that if today's rates of decrease in the level of specific labor costs are maintained in the subindustry of the Ministry of the Petroleum Industry, the personnel strength must rise considerably above today's level. Apparently, there is a single alternative here--technical progress and improvement in how production and labor are organized. Drawing up an integrated program on cutting back the specific personnel strength determines the planning of the rates of technical progress. On these grounds, the planning of scientific and engineering progress must ensure the carrying out of plan for gains in production and in labor productivity.

This means that the existing planning procedures must be completely altered--scientific and engineering progress must be planned for specified directive indicators, and the plans as such must contain a target for allied industries and scientific research organizations to develop and make the kind of product that would ensure higher production efficiency.

The petroleum industry, like any other, is the biggest industrial system for which the planning of future growth and effective functioning requires well-defined interrelationship of all constituent subsystems aimed at reaching the final goal.

In the drawing up of plans for the long-term growth of the industry, the integrated character of the solution of economic problems considered or not considered here must be ensured.

In this respect, economic scientific research organizations will be confronted with new and complex tasks in improving the economic mechanism of controlling the industry and boosting oil production effectiveness.

The most important of these tasks are:

investigation of correlations and factors of industrial growth and national-economic and intra-industrial proportions and the development on this basis of models for optimizing the growth of industrial output for the long term

determination, with allowance for scientific and engineering progress, of the level of technical and economic indicators of the industry's growth in the long term

improving the economic mechanism of control of the industry, in particular, boosting the scientific level of planning, increasing the effectiveness of economic levers and stimuli and further improvements in the organizational structure and management methods

hunting for reserves and developing ways and means of applying them to boost the effectiveness of capital investments, use of fixed assets and return on capital, to lower production costs, raise labor productivity and make better use of material and labor resources.

Several investigations and developments have been conducted along these directions during the years of the Eighth and Ninth five-year plans in the industry; they played a considerable role in the growth of the petroleum industry and in improving the economic mechanism of managing the industry.

The new long-term period of growth calls for further expansion and deepening of investigations in the directions mentioned above and raises to the fore many new complex economic and social problems; on high-quality, scientifically sound solutions to these problems hinges an increase in the effectiveness of social production.

The currently drawn up plan for economic studies for the long term--in the All-Union Scientific Research Institute of the Organization and Control of the Oil and Gas Industry--calls for dealing with a broad scope of industry-wide economic problems corresponding to the tasks posed by the decisions of the 25th CPSU Congress for the petroleum industry.

In the long-term period being planned for, continuous engineering progress --the designing and building of forward-looking technological processes and new equipment--will bring about deep-seated shifts in the economics and organization of production, labor and management.

These changes will necessitate further improvements in the system of economic management of the industry--bringing it into correspondence with new industrial engineering, economic and organizational conditions taking shape in the industry.

Here we have touched only on some economic problems that must be taken into account in predicting the growth of the petroleum industry.

An important task of the scientific and production collectives is uncovering, studying and activating the complex of all economic levers aimed at boosting the effectiveness of oil production.

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ECONOMIC EFFECTIVENESS OF NEW METHODS BOOSTING STRATAL OIL RECOVERY

Moscow EKONOMIKA NEFTYANOY PROMYSHLENNOSTI in Russian No 7, Jul 79 pp 26-30

[Article by I. V. Balashova, P. V. Dergunov, N. M. Nikolayevskiy, N. G. Pekun and V. Ya. Prikhod'ko, All-Union Scientific Research Institute of Petroleum and Gas]

[Text] This article looks at some methodological questions of the economic substantiation of new methods of boosting the oil recovery of strata in the designing stage. Treatment of these problems is necessary, first, in order to delineate from economic points of view the conditions and limitations of applying in the industry new methods boosting oil recovery and, second, substantiating the selection of the most rational method and a variant of its technology in physical-geological conditions for exploiting a specific field.

As per methodological principles for determining the effectiveness of new equipment of the GKNT SSSR [State Committee for Science and Technology of the USSR] and the USSR Academy of Sciences [1], a comparative economic evaluation of exploitation variants must be done at the level of prorated costs $(З = С + Е_н К)$ and a calculation of the annual economic benefit, which is defined on the assumption that the variants are comparability--as to production volume, by method of substantiating economic indicators and by cost standards [2].

The main indicators needed to substantiate and select the most effective method of boosting oil recovery are as follows: lumes of additional oil obtained by applying the method, capital investments and operating costs which are calculated under each of the methods being compared by years and as a whole for the period when the method is being applied.

As already remarked, a comparison of the methods must be done with equal product volumes.

We adopt, according to the decision of the Scientific and Engineering Council of the Ministry of the Petroleum Industry, the method of equalizing the shortfall volume of oil recovery (in the variant with a lower oil recovery) through the conditional involvement in exploitation of new oil reserves with an estimate of their development based on costs necessary for exploiting the relatively poorer new fields provided for in the scope of the current five-year plan.

In accordance with this equalizing of the variants as to product volume, the absolute total of prorated costs must be refined in the variant with lower oil recovery (base variant). This total is defined by two components: costs under the base variant and costs necessary to compensate for the shortfall oil volumes in the base variant. The latter are determined based on the standard for the limiting (maximum allowable) costs and an increment in oil recovery obtained through the new method of exploitation that boosts oil recovery.

This standard for limited costs $(З'_н)$, confirmed in the established procedure, includes costs for prospecting and exploiting new, relatively poorer fields that are assumed as the closing sites introduced into the long-term plans.

It is calculated under the formula:

$$З'_н = (C'_б + C'_р) + E_н(K'_р + K'_{об}) \qquad (1)$$

where $З'_н$ is the level of limiting costs needed to get the shortfall product volume, ΔQ in the variant with the lower oil recovery (base) applied as the single industry standard, rubles/ton

C' is the cost of oil recovery under the traditional development method, rubles/ton

C'_p is the deductions for geological exploratory work, rubles/ton

K'_p is the specific capital investments in exploration, rubles/ton

$K'_{зоб}$ is the specific capital investments in exploiting the field by a conventional method, rubles/ton

Application of a single standard for the industry eliminates the existing disconcordance in ways of looking at an evaluation of new methods boosting oil recovery and what is important--will help determine more fully their national-economic effectiveness.

As we know, for example, suggestions have been advanced for assuming as the limiting costs for evaluating new methods the costs for setting up new capacities in oil recovery formed either on an industry-wide average or for successive oil fields in the region. Both these suggestions cannot be adopted in evaluating a new technology boosting oil recovery. Use of the new methods ensures an increase not only in the completeness of withdrawal during the exploitation period of the reserves, but also an increase in

current recovery levels, liberating resources of labor and material means at new sites needed to meet the industry's growth plan.

Quite naturally, this liberation is best done at the expense of the worse locations prepared for exploitation. So it becomes obvious, as a result, that this "replacement" of the worse objects of additional recovery through the new methods provides favorable conditions for technical advances in boosting oil recovery and measures up to the demands of augmenting the national-economic effectiveness of the new methods.

Calculation of the annual economic benefit from introducing new methods of development is determined, on the average, during the period of exploitation of the fields under the formula

$$Э = [(C'_1 + E_н K'_1) Q_1 + З'_н \Delta Q] - (C'_2 + E_н K'_2) Q_2. \qquad (2)$$

where C'_1 is the cost of oil recovery in the base variant without deductions for exploration, rubles/ton
K'_1 is the specific capital investments in the base variant, rubles/ton
C'_2 is the cost of oil recovery in the variant with augmented oil recovery without deductions for exploration, rubles/ton
K'_2 is the specific capital investments in the variant with augmented oil recovery, rubles/ton
$E_н$ is the standard factor for effectiveness of capital investments ($E_н = 0.15$)

It must be noted that to uncover the savings in exploratory work when calculating the annual benefit from the new method according to Eq (2), the deductions for exploration in C'_1 and C'_2 do not have to be provided for, since these savings show up in the form of $З'_н$ and the repetition of the same deduction value in the variants under comparison (in C'_1 and in C'_2) becomes meaningless, since these deductions mutually cancel out.

When the new method augmenting the oil recovery is introduced at fields that have already completed development with the use of the base technology, or at fields whose development is unfeasible with conventional methods, the annual benefit of the new technology can be calculated according to the following formula:

$$Э = (З'_н - З'_з) \Delta Q \qquad (3)$$

where Q is the increment in oil recovery through the new method, tons
$З'_з$ is the prorated costs per ton of additional oil, rubles

The economic indicators (capital investments and operating costs) in the exploitation methods under comparison are determined by directions of capital construction and elements of the consolidated current costs in accordance

with the technological indicators adopted under each development method (the base method, with the new technology) and with the cost standards under the existing calculation method [2].

The standards for capital investments and operating costs used in planning new methods can be expressed in the form of curves describing the costs as a function of the corresponding technological indicators of field development.

The standards for capital investments by directions of activities in field surface buildup are as follows: equipping wells for exploitation, oil collection and transportation, preparation of crude, flooding system, treatment facilities and so on, have the following form:

$$K' = a z^{-b}[\beta(K'_{смр} - K'_{об}) + K'_{об}] \tag{4}$$

where a and b are the constants in the curve of the dependence of the standards

z is the technological indicator adopted in calculating the corresponding cost standard

β is the share of construction and installation in the standard

$K'_{смр}$ and $K'_{сб}$ are the corrective regional coefficients for the construction and installation work in the standard, respectively

The standards for the capital investments in petroleum collection and transportation and the system of stimulation (steam pipelines, air pipelines and gas pipelines) are determined with allowance for the corrective coefficients that take into account, variant by variant, the differences in the well networks.

The capital investments standard (standard for operating costs) in oil preparation is determined with allowance for the corrective coefficient for the extent of product watering.

The main technological equipment indicators used in evaluating new methods for determining capital investments and operating costs, as we know, are assumed as follows: volumes of additional oil, consumption of working agents, extent of special pipelines needed for carrying out the corresponding process, re-equipping of producing wells under pressurization and the drilling and equipping of additional wells, if this is required for carrying out the method. Corresponding to these indicators are the volumes of capital investments and operating costs, which according to the established procedure must be determined by years and by stages of development of the oil field.

The specific capital investments, variant by variant, during the development years are determined by allocating the accumulated capital investments to the annual oil recovery, namely:

$$K'_i = \frac{\sum_{i=1}^{i=n} K_i}{Q_i} \tag{5}$$

where K_i' is the specific capital investments in oil recovery by variant in the i-th year of development, rubles/ton

$\sum_{i=1}^{i=n} K_i$ is the accumulated capital investments in oil recovery, including the i-th year of development, thousands of rubles

Q_i is oil recovery by variant in the i-th development year, thousands of tons

The mean-annual specific capital investments in oil recovery (K) for the calculated period of development (5, 10 or 15 years) are determined with allowance for the use of capital investments in time:

$$K = \frac{K_1(n-0{,}5) + K_2(n-1{,}5) + K_3(n-2{,}5) + \cdots 0{,}5\,K_n}{\sum_{i=1}^{i=n} Q_i} \qquad (6)$$

where $K_1, K_2, \ldots, K_n$ are the annual capital investments in oil recovery by development variant

n is the number of years in the period

is the accumulated oil recovery in the period under study, thousands of tons

The additional operating costs under the new methods are made up of costs for operating the specialized equipment necessary in carrying out the new method, reagent costs, including transportation costs in its delivery and costs for extracting, transfer-pumping, preparation and storage of additional volumes of oil recovery.

The cost of the additional oil is calculated by the formula:

$$C'_{д} = \frac{C'_{упр}\,\Delta Q + (Ц_р + C'_{эу})P}{\Delta Q} \qquad (7)$$

where $C'_{упр}$ is the conditional-variable costs associated with extracting the additional oil, rubles/ton

$Ц_р$ is the cost of the working agent, including transportation costs, rubles/ton

$C'_{эу}$ is the costs in operating the installations associated with pumping the working agent (depreciation of installations, wages, electric power costs, fuel costs and so on at the installations), rubles/ton

P is the consumption of the working agent, tons

These are the principal, as it appears to us, methodological procedures for determining the technical and economic indicators needed for an economic evaluation of the effectiveness of the new methods boosting the oil recovery. The proposed formulas make it possible not only to substantiate the selection of the variant, but also to analyze the effect of the physical-geological parameters of the reservoir for performing the technological and technical and economic tasks of designing in this area.

In recent years, jointly with the scientific research institutes of the regions, work has been done in the All-Union Scientific Research Institute of Petroleum and Gas (with participation by the authors) on the technical-economic substantiation of application of the new methods of development boosting oil recovery.

An economic analysis of data obtained from generalizing these studies made it possible to find the effect of the assumed level of standard $З_н'$ on the solution of a series of design and planning tasks in this area, namely on the selection of the method and boundaries to its application, on the sequence of introduction of the project and a comparative evaluation of the effectiveness of methods boosting oil recovery.

Table 1 presents the effect of different variants in a fairly broad range of values on the scales of application of the new methods and their distribution by kinds of stimulation. In spite of the conditional nature of the calculation, Table 1 shows that when the limiting costs standard is raised to 60 rubles/ton, the volume of additional oil for the locations under comparison can be nearly doubled. In addition, the share of recovery of additional oil by individual methods boosting oil recovery is found.

Table 1. Additional Oil Recovery from New Methods, for Different Values of the Closing Costs Standard, percent

(1) Метод вытеснения нефти	(2) Варианты предельных затрат, руб/т			
	15	30	45	60
Растворами ПАВ (3)	25,2	25,2	26,4	26,4
(4) Полимерными растворами	12,8	13,1	13,6	13,6
(5) Щелочными растворами	7,7	7,9	7,9	7,9
(6) Газом высокого давления	1,5	5,4	5,8	5,8
(7) Водогазовыми смесями	—	6,2	7,4	7,9
(8) Двуокисью углерода	0,6	4,1	6,0	6,3
(9) Серной кислотой	7,2	7,2	7,2	7,2
(10) Горячей водой	2,1	2,1	2,1	2,1
(11) Оторочкой пара	0,1	4,1	8,0	11,2
(12) Влажное внутрипластовое горение	3,8	9,2	12,1	12,6
(13) Итого	61,0	84,5	95,5	100,0

Key:
1. Method of oil displacement
2. Variants of limiting costs, rubles/ton
3. With surfactant solutions
4. With polymer solutions
5. With alkali solutions
6. With high pressure gas
7. With water-gas mixture
8. With carbon dioxide
9. With sulfuric acid
10. With hot water
11. With steam edging
12. Wet in-situ combustion
13. Total

Table 1, however, does not give us an idea of the economic effectiveness of this increment. Using the same standards for the limiting costs, we calculated the annual savings according to Eq (3) from using the above-examined methods of stimulation, which is shown in Table 2.

Table 2. Annual Economic Effectiveness of New Methods of Oil Field Development, millions of rubles

(1) Метод вытеснения нефти	(2) Варианты норматива предельных затрат, руб/т	
	15	60
Растворами ПАВ (3)	26,3	65,4
Полимерными растворами (4)	−9,4	508,8
Щелочными растворами (5)	−6,9	315,6
Газом высокого давления (6)	−64,2	232,5
Водогазовыми смесями (7)	−186,6	95,7
Двуокисью углерода (8)	−250,7	11,7
Серной кислотой (9)	63,3	425,1
Горячей водой (10)	0,06	84,7
Оторочкой пара (11)	−53,4	406,1
ВВГ (12)	−79,1	1115,7
Итого (13)	−560,6	3261,5

Key:

1. Method of oil displacement
2. Variants of limiting costs norm, rubles/ton
3. With surfactant solutions
4. With polymer solutions
5. With alkali solutions
6. With high pressure gas
7. With water-gas mixtures
8. With carbon dioxide
9. With sulfuric acid
10. With hot water
11. With steam edging
12. Wet in-situ combustion

It is found that at a standard of 60 rubles/ton, all the above-considered methods are effective, and at a 15 rubles/ton level most new methods cannot be adopted for introduction, which lays emp[illegible]is on the problem's importance.

The effect of the costs standard (3) on the limiting technological effectiveness of the method is found by using the indicator of the minimum attainable "yield" of additional petroleum per ton of pumped reagent, placed in dependence on the amount of operating costs in pumping 1 ton of reagent (including reagent cost).

Presented in the figure are these functions by kind of stimulation on the stratum that give the minimum attainable "yields" of product per reagent ton for different specific values and operating costs in reagent pumping.

Thus, for example, the method of pressurizing sulfuric acid (H_2SO_4) can be adopted for introduction if the design or actual indicators for reagent pressurizing will be more favorable with respect on comparison with the limiting values of the indicators (figure).

So when the operating costs in pumping 1 ton of sulfuric acid are 50 rubles (see figure) and when the standard of the limiting costs is 15 rubles/ton ($З_н$), the minimum attainable additional oil recovery per reagent ton is 3.3 tons, and when the standard is $З_н$ = 60 rubles/ton, the minimum additional oil recovery lowers to 0.9 ton per reagent ton, which means a considerable expansion in the limits of the method's applicability.

The economic effectiveness of the new methods boosting oil recovery, as we know, is strongly affected by the physical-geological parameters of a pool.

The investigations conducted in the All-Union Scientific Research Institute of Petroleum and Gas helped establish, from the materials of 64 hypothetical pools and 756 variants, using correlation analysis, the following dependences of oil recovery costs on the geological parameters of a location when there is thermal stimulation on the stratum, namely:

with wet in-situ combustion

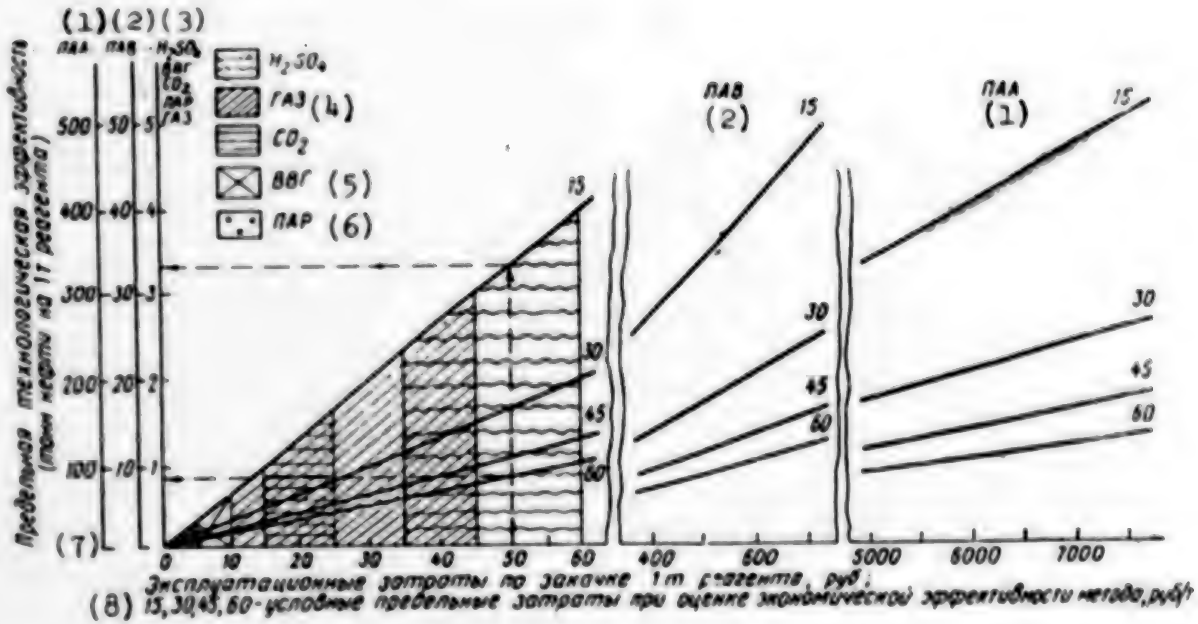
$$C_{вш} = 3{,}4186\left[h^{-0{,}176}\left(\frac{12\cdot 10^{-4}\cdot H}{h^{0{,}505}}+1\right)\times \times m\beta^{-0{,}962}\, Q_{бал}^{0{,}0776}\cdot R^{-0{,}3217}\right] \quad \text{rubles/ton} \qquad (8)$$

with steam pressurizing

$$C_{п} = 1{,}04h^{-0{,}907}\cdot H^{0{,}78} m\beta^{-0{,}568} Q_{бал}^{-0{,}032}\cdot R^{0{,}126} \quad \text{rubles/ton} \qquad (9)$$

where H is the bedding depth of the producing stratum, meters
h is the stratum thickness, meters
$m\beta$ is the oil saturation
$Q_{бал}$ is the balance oil reserves by the beginning of the method's application
R is the well spacing network, hectares

Analysis of the resulting functions showed that the influence of each parameter differs widely. The strongest effect with wet in-situ combustion on oil recovery costs is oil content ($m^{-0.962}$) and the well spacing network ($R^{-0.3217}$).



I iting technological effectiveness as a function of reagent pumping cost

Key:

1. Surface-active agent
2. Surfactant
3. H_2SO_4 / Wet in-situ combustion / CO_2 / Steam / Gas
4. Gas
5. Wet in-situ combustion
6. Steam
7. Limiting technological effectiveness (tons of oil per ton of reagent)
8. Operating costs in pumping 1 ton of reagent, rubes; 15, 30, 45 and 60 are the conditional limiting costs when evaluating the economic effectiveness of a method, rubles/ton

Stratal thickness ($h^{-0.907}$), stratal bedding depth ($H^{0.78}$) and well spacing network ($R^{-0.426}$) have the strongest effect on oil recovery costs when steam-heat stimulation is used.

Oil recovery costs are least affected, under both methods, by the size of oil reserves (under otherwise equal conditions).

These characteristics and analogous characteristics for other kinds of stimulation, typifying the association of the process economics with geological and technological factors, have much significance in the selection and evaluation of new methods of boosting oil recovery.

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ECONOMIC EVALUATION OF NEW OIL RECOVERY BOOSTING METHODS IN BASHKIR

Moscow EKONOMIKA NEFTYANOY PROMYSHLENNOSTI in Russian No 7, Jul 79 pp 32-34

[Article by S. A. Ponomarev, P. I. Babalyan, and P. A. Berezovskiy, Bashkir Scientific Research Institute for Petroleum Refining, Bashneft' Association

[Text] A fairly large number of new methods of artificially stimulating petroleum beds is now known and many have found commercial application. The theory and practice of applying carbon dioxide (CO_2) and surfactants in oil field development have been worked out in the Bashkir Scientific Research Institute for Petroleum Refining. Under testing at Bashkir oil fields for these purpose are polymers, sulfuric acid and thermal methods (pumping of steam and hot water); laboratory studies of the effectiveness of micellar solutions and so on are going on.

Bed stimulation measures are being economically evaluated at all stages of their investigation and application--from the technical-economic substantiation for setting up laboratory studies to wide-ranging commercial introduction.

In recent years technical-economic substantiation on using chemical methods of boosting oil bed recovery has been carried out in the Bashkir Scientific Research Institute for Petroleum Refining: surfactants and CO_2 for the industry as a whole, CO_2 in Bashkiria and in the Abdrakhmanovskaya area in Tataria. A number of developmental plans have been drawn up for oil fields that make use of surfactants and CO_2, including areas like the Arlanskoye and the Tuymazinskoye. Systematically, the actual effectiveness of applying stimulation methods on beds in the Bashkir fields is receiving an economic analysis.

Through this work, in the institute a certain amount of experience has been accumulated in the economic evaluation of new methods of stimulating oil beds, permitting some generalizations.

Analysis of the best-known methodological studies, as well as the institute's operating experience in this activity reveal that an economic evaluation of bed stimulation methods can proceed by determining the comparative economic benefit and by determining the total (absolute) effectiveness.

The comparative economic benefit is calculated by comparing the development variants. Taken as the base is the development variant that does not use bed stimulation.

A necessary condition for calculating the relative economic benefit is compliance with the comparability of the variants by volume of recovered oil and duration of period in question and by methods of calculating the value indicators and the prices assumed in finding the costs and benefit.

The development variants can be equalized by volume of oil recovered only through specific measures (putting new fields into development and altering the technology of exploiting an already developed field), permitting an increment in oil recovery equal to the recovery from carrying out the bed stimulation method.

The method of calculation by difference in prorated outlays is most applicable for estimating technological solutions for an equal volume of oil recovery in an identical time period, that is, determining the comparative economic benefit helps answer the question, how much more effective the proposed bed stimulation method is compared to other methods making it possible to get the same volume of oil recovered.

One drawback for this method of evaluation is that it does not permit finding the size of the benefit directly from the increase in the rates of recovery of the same amount of oil in earlier periods.

In addition, this evaluation method does not permit a response to the question as to how effective are measures that result in an oil increment at costs equal to or greater than the cost level in the base variant.

These factors can be allowed for by the allowable level of closing costs adopted for the industry in the long-term period, when the increment in oil recovery is evaluating the increment in oil recovery from a technical measure.

Calculating the total (absolute) economic effectiveness of the new technique is usually done using wholesale prices for the oil. But under this evaluation we must keep in mind that the system of prevailing wholesale prices for oil serves the goals of ensuring the economic cost-accounting (current) activity of oil-recovery enterprises and does not overreach the scope of this task.

But the oil wholesale prices for each region and for the industry reflect averaged and so relatively time-stable conditions of oil recovery. But the

Economic Effectiveness of Pumping Surfactants and CO_2 Into Oil Beds, Under Different Variants (Maximum Allowable) Costs*

(1) Объединения	(2) Варианты замыкающих затрат, руб/т							
	20		40		60		80	
	ПАВ (3)	CO_2	ПАВ (3)	CO_2	ПАВ (3)	CO_2	ПАВ (3)	CO_2
«Башнефть» (4)	—	—	+	+	+	+	+	+
«Татнефть» (5)	+	—	+	—	+	—	+	+
Главтюменнефтегаз (6)	+	Не рассм.	+	Не рассм.	+	Не рассм.	+	Не рассм.
«Пермнефть» (7)	—	—	+	—	+	+	+	+
«Азнефть» (8)	—	Не рассм.	+	Не рассм.	+	Не рассм.	+	Не рассм.
«Коминефть» (9)	—	Не рассм.	+	Не рассм.	+	Не рассм.	+	Не рассм.
«Куйбышевнефть» (10)	Не рассм.	(13)	Не рассм.	+	Не рассм.	+	Не рассм.	+
«Белоруснефть» (11)	Не рассм.	—	Не рассм.	—	Не рассм.	+	Не рассм.	+
«Мангышлакнефть» (12)	Не рассм.	—	Не рассм.	+	Не рассм.	+	Не рассм.	+

* Plus sign stands for effective, minus sign--for ineffective

Key:

1. Associations
2. Variants of closing costs, rubles/ton
3. Surfactants
4. Bashneft'
5. Tatneft'
6. Glavtyumenneftegaz
7. Permneft'
8. Azneft'
9. Komineft'
10. Kuybyshevneft'
11. Belorusneft'
12. Mangyshlakneft'
13. Not examined

development of each individual field is characterized by an increase in costs for oil recovery as the reserves are exploited. So the economic benefit for an individual field cannot be evaluated for a lengthy period of time by wholesale prices.

Let us turn now directly to evaluating surfactants and CO_2 based on the above-indicated materials of technical and economic substantiation.

Given in the table are data characterizing the design levels of prorated outlays for the recovery of one ton of additional oil when surfactant and CO_2 solutions are pumped into oil beds.

The table was compiled from design materials prepared in the Bashkir Scientific Research Institute for Petroleum Refining from technical and economic substantiation of surfactants and CO_2 used on a large commercial scale. As shown by calculations, pumping chemical reagents in the planned volumes for the groups of fields under consideration makes it possible to considerably increase oil recovery from oil reserves. The final oil recovery factor, from the institute's calculations, goes up by 4-10 percent when surfactants are pumped in, and by 6-20 percent when carbon dioxide is pumped in. But even here the level of costs in recovering the additional oil will be high (for some fields, two to three times greater than the costs in oil recovery in these same fields without bed stimulation methods).

To us it appears that when an economic evaluation is made of new methods of bed stimulation, the additional oil must be viewed as oil that cannot be recovered by traditional methods, and even if it could be, it would be at costs much higher than the allowable cost level set up as long ago as 1971.

The new methods offer the possibility of augmenting, to some extent, the capacity for oil recovery. Under this approach to the economic evaluation, it is valid to compare the costs in recovering the additional oil with the costs for commissioning new capacities in oil recovery provided in the plan. Here as the basis for comparison we must apply the closing costs reflecting the allowable level of costs in exploiting deposits with the worse natural conditions.

Consonant with this, results of economically evaluating surfactants and CO_2 from technological data and data of the above-presented table will be as follows: when, for example, the closing costs are used at a level of 40 rubles/ton as the limiting standard, it will be economically ineffective to pump CO_2 at the Tatneft', Permneft' and Belorusneft' field, while surfactants are effective in all these regions named; when the closing costs are 60 rubles/ton, pumping CO_2 is not effective only in Tatneft'; when the costs are 80 rubles/ton, both methods of stimulating the beds in all the locations considered must be held economically effective.

To this it must be added that data shown in the table characterize the initial pumping period, with the highest chemical reagent flow rate. When the pumping results are evaluated over the entire period of field development, the costs per ton of additional oil will be much lower.

Of course, the concept "worse field" is relative. It is defined by the total planned oil requirement (in petroleum products), by the amount and quality of proven reserves, level of technology, location factors, levels of economic indicators and so on. With time, as technical progress moves on in oil recovery and as there are changes in the structure of the reserves, other fields will be classed in the category of "worse." But right now this concept is wholly specific, and the level of closing costs for developing these new oil fields can be taken as the limit to costs for oil recovery by applying technological methods boosting oil yield.

The cost level must be determined in a centralized way and refined with increasing changes in the economic conditions of the industry's growth.

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ECONOMIC EVALUATION OF STEAM-HEAT STIMULATION OF USINSKOYE FIELD HEAVY CRUDE

Moscow EKONOMIKA NEFTYANOY PROMYSHLENNOSTI in Russian No 7, Jul 79 pp 34-37

[Article by L. A. Pukhova, Pechora Scientific Research and Planning Institute of Petroleum]

[Text] The geological and technological parameters of heavy crude pools predetermine the need for development methods that would boost the final oil recovery of the bed. Since the selection of the development method is based on an economic evaluation of applying methods that augmenting the oil recovery of the bed, generalizing experience in making this evaluation is most significant. In the Komi ASSR the economic evaluation of methods augmenting the oil recovery of beds can be examined with the example of calculations made from design materials of the exploitation of the Permian-Carboniferous pool of Usinskoye field heavy crude.

Presented in this article is a comparison of two variants of developing the high-viscous crude of the Usinskoye field: in the natural regime and by pumping steam into the bed.

The choice of the development method is based on a comparison of variants by indicators characterizing the oil recovery volumes, the oil recovery cost levels, the capital investment levels and the savings based on deductions for geological exploration associated with boosting the final oil yield of the bed.

Taken as the period of comparison is the principal development period, which is the period of exploitation of the recoverable reserves when the pool is exploited by the above-indicated development methods.

Pumping steam into a bed, compared with pool development in the natural regime makes it possible to increase the final oil yield and thereby to increase the economic effectiveness of development through expanding the resources of the recoverable reserves and accelerating the oil recovery rates.

Theoretical and laboratory studies by the institutes VNIIneft' [All-Union Scientific Research Institute of Petroleum and Gas] and PechorNIPIneft' [Pechora Scientific Research and Planning Institute of Petroleum] showed that steam pumping into a bed compared with the natural regime of pool development makes it possible to boost the oil yield by four to five times.

The additional oil recovery through steam pumping into the bed at the Usinskoye field was defined as the difference between the calculated values in oil recovery under the compared variants for the principal development period.

In contrast to pool development in the natural regime, when steam is pumped into the bed there are added costs tied in with the process and costs needed in recovering the additional oil volume. Classed with these costs are expenditures in electric power in recovery of the additional oil and in its collection, transportation and treatment.

Costs in pumping steam and water at the Usinskoye field were determined from an analysis and mathematical treatment of actual costs in steam and water pumping at the Yareganeft' NShU in the 1971-1977 period. From the calculations, the anticipated cost calculations of 1 ton steam and 1 m^3 water were compiled.

The costs for electric power in recovery of the additional oil and for its collection, transportation and treatment were determined according to methodological guidelines given in the study [1], using the actual data of the Usinskneft' NGDU [oil and gas production administration].

The remaining costs, assuming an equal number of simultaneously operating producing wells by variants, will be the same. When there is a different number of producing wells and a different exploitation period, the savings (overexpenditure) in costs can be established by comparing, variant by variant, the general-production costs, depreciation deductions and the well operating costs [2].

Development of a field with steam pumped into the bed is associated with added capital investments. The main directions in the added capital investments are as follows: water supply to the boiler installation (water intake, lift I and lift II pump levels, water conduits and treatment plant); gas supply to the boiler installation (gas pipelines and gas distributing station); fuel department (tanks for storing mazut, mazut pump installations and tanks for storing diesel fuel); commercial pump installations, steam pipelines, steam-absorbing wells, well-head fixtures for steam pumping, deemulsifying installations and treatment plant (water conduits, settling tanks and absorbing wells). When the steam is pumped in combination with flooding for the locations described above, a final-stage pumping station is added for pumping water into the bed.

Since under the variants compared an equal number of producing wells was assumed, the capital costs dependent on the number of wells are equal for these variants.

Therefore, to find the capital investments by the steam-pumping development variant, to the capital investments calculated for the variant without maintenance of bed pressure must be aided capital investments for the above-mentioned additional locations.

To make a comparison of variants by volume of capital investments, we need to present them in a comparable form, that is, we must allow for costs that are required for making the same product in the same volume. To meet this condition, we can assume that the oil volume that is shortfall under the variant without bed pressure maintenance compared with the variant of development with steam pumping will be obtained at other reas with the same development conditions. But no new heavy viscous crude beds have been discovered in the region at the present time. Of the fields under development, we can cite as a "closing" field only the Yaregskoye heavy crude field. But it is being developed by the heat-shaft method, so its development indicators cannot be used in calculations for equalizing the variants.

Considering the foregoing, to comply with the conditions of variant comparability, the capital investments at the shortfall oil recovery level are determined by starting from the average specific capital investments for a well that are calculated under the development variant without bed pressure maintenance at the same bed, and the number of wells necessary to supply the additional oil recovery in analogous natural conditions.

The difference between capital investments in the steam-pumping development variant and the capital investments in the variant without bed pressure maintenance and additional investments calculated by the above-described method is the savings in capital investments obtained by applying steam pumping into the bed.

The savings in costs in the variant where the bed is treated thermally are also available in preparing the reserves owing to the gain in oil yield of the bed under the effect of steam pumping. In our view, the difference in the total deductions for geological exploratory work, resulting from oil recovery that differs by variants, from the geological reserves of a given pool (for unaltered and variant-identical costs in preparing these reserves) is essentially a savings in costs for geological exploratory activity.

As we know, deductions for the preparation of reserves, reflected in the oil recovery costs for 1 ton of oil are differentiated by oil regions in the form of a standard operating for a number of years. Deductions for geological exploratory activity in this case can be determined as the product of the standard for geological exploratory deductions, established for the Komi ASSR and the oil recovery volume by variants. Therefore, the greater the oil recovery by variant, the larger the sum of deductions

geological exploratory activity, and the higher the oil recovery rates, the faster the costs of geological exploratory activity will be compensated for. By comparing the deductions for geological exploratory work with the actual costs for the discovery and exploration of the given field, we can establish how much the compensation for these costs are larger than the actual costs for each variant.

But if from the difference between the deductions for geological exploratory work and the actual costs under the steam-pumping development variant we subtract the difference between the deductions for geological exploratory work and the actual costs under the development variant without bed pressure maintenance, the value obtained is the savings in costs for geological exploratory work resulting from increasing the final oil yield factor. Regardless of the somewhat arbitrariness of this calculation, the increase in deductions in the steam-pumping development variant reflects the actual savings in preparing the reserves, since the additional oil was obtained by augmenting the recovery from the geological reserves and is not in need of additional exploration. If this is so, the deductions for geological exploratory work carried out for additional oil (less the actual costs) are an expression of this savings in preparing the reserves.

Applying the above-mentioned methodological prerequisites, the indicators of the economic effectiveness of development of the Usinskoye field heavy crude pool are calculated, with steam pumping and without maintaining bed pressure.

Capital investments, variant by variant, were determined under the generally adopted method [2] using the standards for the specific capital investments for surface buildup of the oil fields formulated in Giprovostokneft' [State Institute for Planning and Research in the Petroleum Production Industry] [3].

The capital investments by development variant without bed pressure maintenance, according to our calculations, are 146.8 million rubles, including for drilling--92.4 million rubles. So the specific capital investments per producing well are: for drilling 330,000 rubles and for surface buildup--195,000 rubles.

The additional capital investments associated with steam pumping into the bed are determined in the following directions: drilling injection (steam-absorbing) wells--95.2 million rubles; equipping the well-heads of the steam-absorbing wells with special fittings--2.5 million rubles; water supply and flooding of the oil beds--7.2 million rubles; commercial boiler installations--7.9 million rubles; steam pipelines--0.2 million rubles; and the total--113 million rubles.

As the steam passes into the bed, stable emulsions form; when they surface (at the well-head), the emulsions retain their high temperatures. So the composition of the equipment that is part of the deemulsifying installation

and the treatment plant changes. Climbing construction costs of the installation for treatment of heavy crude are estimated to be 1.3 times and for the treatment plant--1.5 times.

In addition, the cost of constructing these projects depends on the volume of recovery of the liquid arriving for deemulsification and purification.

In our case, the capital investments for crude preparation and for the treatment plant under the steam-pumping development variant are 5.6 million rubles, while under the development variant without bed pressure maintenance--3 million rubles. The total of capital investments under the steam-pumping development variant is 262.4 million rubles.

In order to bring the variants in a comparable form, let us determine what number of wells must be additionally drilled so as to get an oil recovery level projected under the steam-pumping development variant, but in the natural regime.

In analogous locations 958 wells have to be drilled to attain the additional recovery. Capital investments for drilling these additional wells are 316.1 million rubles and for commercial surface buildup--186.8 million rubles.

So the capital investments for the development variant without bed pressure maintenance in analogous natural conditions will be 649.7 million rubles.

By comparing the resulting volume of capital investments with the volume of capital investments under the steam-pumping development variant, we find the savings in capital investments is: 649.7 - 262.4 = 387.3 million rubles.

Calculation of the savings in deductions for geological exploratory work under the variants being compared is made with the use of the standard for deductions for geological exploratory work for the Komi ASSR (2.45 rubles per ton). On this basis, the total deductions for geological exploratory work in the development variant without bed pressure maintenance will be 21.07 million rubles and under the steam-pumping development variant--93 million rubles.

Actually, 6 million rubles is expended for discovery and exploration of the given pool.

By comparing the total standard deductions with the actual costs, we find the value of the compensation for the costs in geological exploratory work under the development variant without bed pressure maintenance: 21.07 - 6.00 = 15.07 million rubles and under the steam-pumping variant: 93.0 - 6.0 = 87.0 million rubles.

Therefore, from steam-pumping the savings in preparing the reserves, expressed as the difference in the deductions for geological exploratory work,

will be: 87.00 - 15.07 + 71.93 million rubles. As a whole, the economic benefit from steam pumping into the bed when development the heavy crude pool of the Usinskoye field for the principal period is characterized by a savings in capital investments in development of 387.3 million rubles and a savings in exploration (in terms of deductions for geological exploratory work) of 71.93 million rubles.

Application of thermal stimulation on a bed by steam pumping at the Usinskoye field, as shown by the above-presented calculations, is characterized by a considerable economic benefit.

The proposed method of calculating the effectiveness indicators can be used in making an economic substantiation of the oil recovery techniques in technological arrangements and project plans for exploiting oil fields with high-viscous crude pools.

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ECONOMIC EVALUATION OF NEW OIL RECOVERY EQUIPMENT, TECHNOLOGY

Moscow EKONOMIKA NEFTYANOY PROMYSHLENNOSTI in Russian No 7, Jul 79 pp 38-39

[Article by B. A. Starodubtseva, Kazakh Scientific Research and Planning Institute of Petroleum]

[Text] The rapid tempo of scientific and engineering progress and the profusion of scientific developments demand a careful approach to selecting the best way of working out a particular engineering problem.

This selection, in turn, depends on how advanced is the method of economically evaluating the new equipment and the new technology that is introduced. The method of evaluating the economic effectiveness of the proposed measures offers the opportunity of determining how far each measure is technically progressive: should it be accepted for introduction; what economic benefit does it bring.

A distinction is drawn between the general (absolute) and comparative effectiveness. Based on the prorated costs we determine the economic effectiveness of one variant of an engineering solution compared with another. A typical method states that a given formula can be applied in the case of equal product quality and product volume, variant by variant, and this is not coincidental. Different product volumes and product quality in the variants presuppose, besides the different costs in making the product, also a different value for the incremental product, which is not reflected in the given formula. So violating this limiting condition does not permit a valid comparison. This is the foundational condition imposed on using the prorated costs in all industries. Here equalizing the product volumes has a real basis in fact, since the shortfall product volume in any of the variants can always be obtained by bringing in extra capacities. Assume that a single metal-working machine tool turns out half the parts production than another machine tool, but at lower costs. Let us install two machine tools like the former and they will turn out the same number of parts as one machine tool that is more productive, but less economical.

Thus, by comparing these two variants we can always ensure identical volumes.

Let us look at what the situation is in the extractive industries, and in petroleum recovery in particular.

We know that many different measures yielding additional oil are carried at in petroleum recovery enterprises.

The prevailing practice of determining the economic effectiveness of these measures is such that they are evaluated with comparison with the developing mean cost level in petroleum recovery at the given petroleum and gas recovery administration. And since the goal of the comparative evaluation lies in selecting the best variant, in the given case the indicators of the "petroleum and gas recovery administration in the absence of the measure" are taken as one of these variants.

It turns out that if these indicators prove to be better, we must give preference to this variant. Even so, the petroleum and gas recovery administration is not capable of giving more petroleum than it provides at the time the measure is introduced. Additionally, this situation then was the cause of conducting stimulation measures.

So an evaluation in terms of cost, even if they are averaged and not true across the industry, but in the petroleum and gas recovery administration, does much to slow down introduction of developments to boost oil recovery and in particular the developments promoting gains in oil yield. If the technical-economic indicators for these developments will be at the level of indicators averaged in the petroleum and gas recovery administration or a little higher, they will fall into the category of ineffective developments. An obligatory orientation at cutting costs is incorrect, first of all, because the measures to raise the oil yield as a rule are costly, and secondly, the overall tendency to modify costs in the oil recovery industry bears witness to their steady growth.

Evaluating a measure at the level of averaged costs for a specific petroleum and gas recovery administration, besides the disadvantages stated above, has one more negative side to it--it is subjective.

Known to us in our experience in planning measures for new equipment is a good number of cases when "rejections" were pronounced on developments that offered an increment in oil recovery but at costs close to those averaged in the petroleum and gas recovery administration. This state of affairs appears incorrect to us, because when new equipment and technology affecting the recovery level is under evaluation in extractive industries, we cannot be oriented just at costs and we cannot divorce our thinking from the incremental product.

It must be stated that in this area a forward move has already been taken. A project plan has been presented in a session of the Scientific-Technical

Council for methodological guidelines in calculating the economic indicators of variants of oil fields and the selection from these of the optimal variant, worked out by the VNII [Scientific Research Institute of Petroleum and Gas].

In this project plan the mean-industry indicators or new capacities are proposed for adoption as the basis. Both these bases have the advantage that they are free of any subjectivity of the production evaluation and are standardized: the calculation results are made comparable and lend themselves to summation.

Let us dwell on this question a while. If we compare the indicators of a particular variant of oil field development with the mean-industry indicators, then the ineffective variants will be the variants for which the costs are greater than the mean-industry costs (even if only slightly so). This does not make sense: how can these variants be ineffective if capacities with even poorer indicators are operating in the industry? So the mean-industry indicators cannot be taken as the basis when finding an answer to the question of comparative effectiveness.

"New capacities" are, in our view, the most universal of the bases of comparison existing thus far. A comparison of a particular development variant (increasing oil yield) with the "new capacities" makes the evaluation realistic, free of any arbitrariness, since a specific measure stands for the new capacities. However, the authors of the method do not lend specificity to the concept "new capacities." Unclear is whether they are one or several; whether they are to be characterized by the best or worse indicators; whether they are to be unified for all or differentiated by regions and, finally, who is to calculate these capacities? To all these questions there is no answer in the guidelines, but in fact these points are very important.

To us it appears that the "new capacity" can be taken as the base of comparison. But it must be the same for all scientific research and planning institute and is to be characterized by the worse technical-economic indicators.

Approximately speaking, this is how it is proposed to find an answer to the questions of the comparative effectiveness of the VNIIOENG, where the "Methods of the Economic Evaluation of Oil Fields" was drawn up; the comparison is made in terms of differential mine rent. This solves the following problems: give an objective evaluation for the proposed variant; take the time factor into account; make the results of the comparative evaluation comparable; and obviate the necessity of equalizing the product volumes by variants, which takes a great deal of time.

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